CO_2 *Mineralization* for *in situ* Storage and *ex situ* Enhanced Metals Recovery

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arpa·e
CHANGING WHAT'S POSSIBLE

Technology or focus area

- Laboratory data and modeling will form the basis of a field-scale experiment that drills two deep wells to inject CO_2 and monitor reaction progress over time in the Snake River Plain basalt, Idaho.

Ideas, Interests, Concepts to be Explored

- CO_2 mineralization in diverse basaltic rocks can be predicted by advanced geologic simulation codes that **integrate nano- to core-scale laboratory experiments and deep borehole geophysical and mineralogical characterization**.

- Large-scale CO_2 sequestration into **diverse Snake River Plain glassy and altered basalts** will be assessed, including fractured intervals with high injectivity beneath low permeability caprock that reduces risk of CO_2 migration into aquifers.

- **Interdisciplinary and collaborative approach.**

CO_2 MINERALIZATION IN BASALT: THERMODYNAMIC, EXPERIMENTAL, AND MATERIAL CONCEPT VALIDATION, SNAKE RIVER PLAIN BASALT, IDAHO

- **Project deliverables:**
- Laboratory-calibrated and field-tested injection model for Snake River plain basalts referenced to cored boreholes from the HOTSPOT drilling project
- Work-flow structure for selection of optimal basalt lithologies for carbonation reactions to be utilized CO_2 mineralization projects in other large USA basaltic provinces

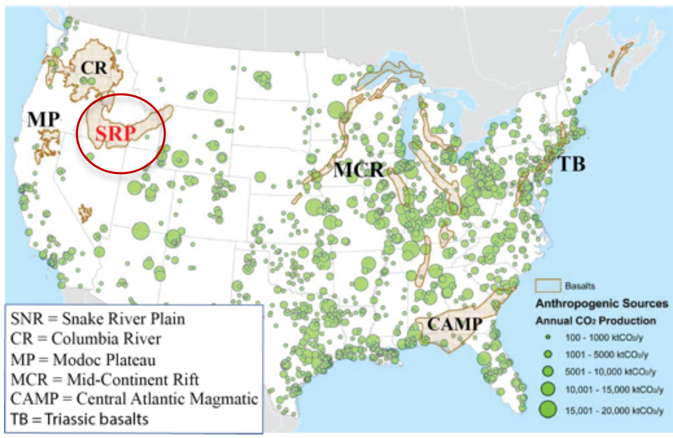

Fig.1. CO2 production in the USA (green). Basaltic Provinces (brown), after McGrail et al. 2006.

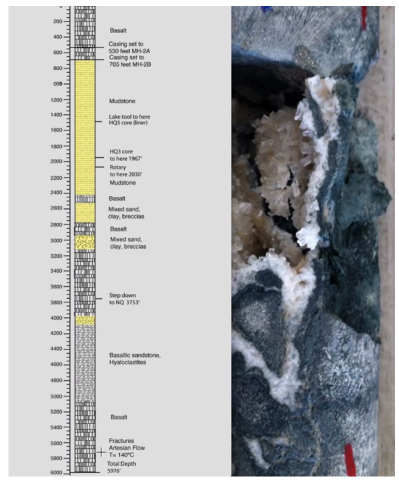

Fig.2. Diverse, glassy and altered basaltic lithologies occur at 25–100 °C and up tp 1.5-1.8 km depth.

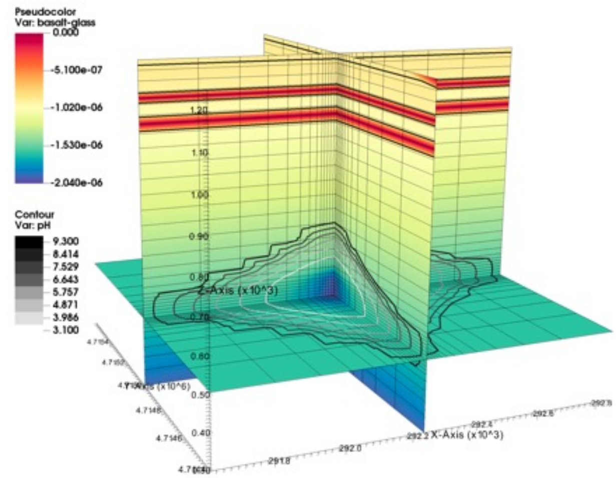

Fig.3. TOUGHREACT simulation of fluid pH (contours) and mineralized fraction of basalt (colors) , 3 months CO_2 injection at 100 kg/s, glassy basalt in a HOTSPOT borehole.

Demonstrate 5-10X improvement in CO_2 injectivity and mineralization compared to current CARBFIX rates (30 t/day) : optimize injection sequences to maximize CO_2 input, mineralization (reactivity), cost (moderate depths) and adequate permeability (fractures) in diverse basaltic lithologies.

CO_2 Mineralization for *in situ* Storage and *ex situ* Enhanced Metals Recovery

Milind Deo
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I am the Peter D. and Catherine R. Professor in the Department of Chemical Engineering at the University of Utah in Salt Lake City and the Interim Director of the Energy and Geoscience Institute, a multidisciplinary institute at the University of Utah. All my degrees are in Chemical Engineering with post-doctoral experience in Petroleum Engineering. I have managed a number of Department of Energy and industrially-sponsored projects in reservoir engineering, enhanced oil recovery, carbon dioxide injection for EOR and sequestration, flow assurance and geothermal energy production. I have supervised the Ph.D. dissertations of 34 students.

Technology or focus area

- *Carbon dioxide properties, sub-surface injection and enhanced oil recovery*
- *Carbon dioxide in situ storage*
- *Mineralization*

Ideas, Interests, Concepts to be Explored

I have worked on CO_2 Enhanced Oil Recovery, sequestration, and mineralization. I believe that under the right conditions, geological formation reactivity combined with right engineering design will offer opportunities for safely mineralizing large quantities of CO_2. We will need to decipher the capacity of the formation for rapid mineralization in relation to the quantities of CO_2 injected. Successful implementations of rapid subsurface mineralizations in the past may be used to realize this objective.

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GEO SCIENCES

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I am an igneous petrologist/geochemist specializing in mafic and ultramafics rocks – basalt, peridotite, serpentine. I was PI/PD of Project Hotspot, an geothermal exploration project in the Snake River Plain, ID, funded by DOE-EERE that cored 3 deep (2 km) holes across southern Idaho, coupled with detailed petrologic, geochemical and geophysical studies. We recently completed another DOE EERE geothermal project in Idaho. I have also worked extensively on ultramafic rocks in the Coast Ranges of California and Oregon, Europe, and the western Pacific (serpentine mud volcanoes), and sailed on two IODP expeditions.

Technology or focus area

- *In situ* carbon mineralization of basalts and ultramafic rocks, with focus on western USA.
- Chemical, mineralogical, and structural aspects of *in situ* mineralization.
- Field-scale validation based on known basalt stratigraphy.

Ideas, Interests, Concepts to be Explored

We seek to understand the chemical dynamics and kinetics of *in situ* mineralization in basalts through static and flow-through experiments, detailed thermodynamic and fluid dynamic modeling using observed phases, and detailed characterization of existing core samples. These studies will guide our field-scale validation experiments, using knowledge gained from 5.3 km of core and detailed geophysical, petrologic and temperature logs obtained in our previous DOE-funded projects. Our goal is to maximize the mineralization potential of different basalt lithologies by exploiting fracture permeability, porous flow tops, and optimal thermal conditions.

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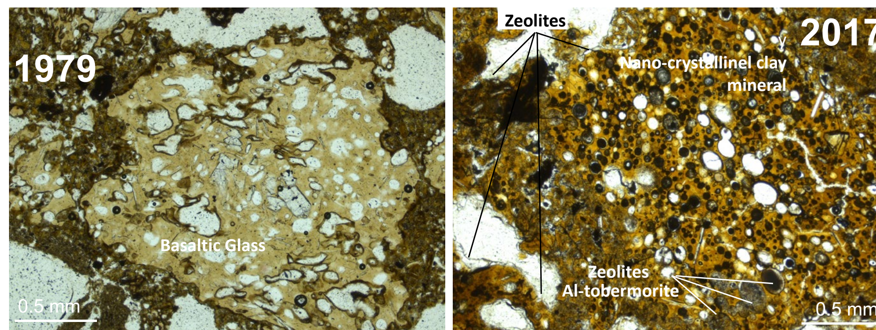
- Research focus: Characterization of authigenic mineral growth – Pyroclastic volcanism – Rock Mechanics – Reactive glass concretes
- PI, ICDP SUSTAIN drilling project, 2017, Surtsey volcano, Iceland. Time-lapse cored boreholes in 50-year-old basaltic tephra and tuff.
- PI, Roman Reactive Glass Concretes, 2019, DOE ARPA-e CEMENT program. Marine concrete infrastructure with artificial tephra aggregate.

Technology or focus area

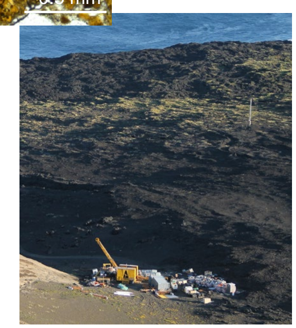
- Rapid alteration of glass in very young basalt
- Mineralization of very young basalt at 25-140 °C, diverse fluid compositions, microbial interaction, Surtsey volcano, Iceland
- Characterization of calcium-aluminum-silicate hydrate minerals in reactive glass concretes

Ideas, Interests, Concepts to be Explored



Rapid, low temperature mineralization of Surtsey basaltic glass provides a reference for CO_2 mineralization in diverse basaltic lithologies and environments.

icdp
INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM



SUSTAIN Drilling, 2017

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Pania Newell
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I am currently an assistant professor in the Department of Mechanical Engineering at the University of Utah. Prior to joining The University of Utah, I was a member of the technical staff at Sandia National Laboratories. My research interest are on coupled processes in heterogeneous systems such as subsurface. In particular, I am interested in multi-scale, multi-physics phenomena in fractured media. I am one of the editors of book entitled "Science of Carbon Storage in Deep Saline Formations: Process Coupling Across Time and Spatial Scales".

Technology or focus area

- Coupled processes in subsurface
- Chemo-mechanical characterization of fractured rock
- Geomechanical characterization across scales

Ideas, Interests, Concepts to be Explored

We seek to understand the chemical dynamics and kinetics of *in situ* mineralization in basalts through static and flow-through experiments, detailed thermodynamic and fluid dynamic modeling using observed phases, and detailed characterization of existing core samples. These studies will guide our field-scale validation experiments, using knowledge gained from 5.3 km of core and detailed geophysical, petrologic and temperature logs obtained in our previous DOE-funded projects. Our goal is to maximize the mineralization potential of different basalt lithologies by exploiting fracture permeability, porous flow tops, and optimal thermal conditions.